DEPARTMENT OF

AEROSPACE ENGINEERING AND MECHANICS

COLLEGE OF Science & Engineering

UNIVERSITY OF MINNESOTA

Department Update - Summer 2021

Welcome Professors Kirsten Strandjord and Melissa Green

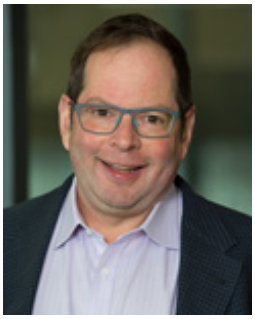
The Department of Aerospace Engineering and Mechanics is pleased to welcome Kirsten Strandjord and Melissa Green as the newest additions to the faculty. Both Strandjord and Green will start in Fall 2021.

Strandjord's joins the aerospace systems group as an Assistant Professor. Her area of research is in Global Positioning System (GPS) and Global Navigation Satellite System (GNSS) technology and applications for positioning, navigation and timing (PNT). Strandjord's research involves characterizing the phenomena of GNSS multipath and the effects on position solutions. She is also active in the area of urban navigation, where she investigates the use of long-term evolution (LTE) signals typically used for communication purposes as signals of opportunity for navigation.

Green joins the fluid dynamics faculty as an Associate Professor. Her research focuses on lift generated by flapping wings, thrust generated by oscillating fins, drag generated by struts and cables, moments generated by a gust hitting an aircraft wing. In all of these scenarios, the interaction of fluid (air, water) with the surface generates coherent structures or motions in the fluid, often in the form of vorticity or distinct vortices. These in turn are often associated with pressure and forces on the surface. In some cases, these interactions are desired and need to be augmented, while in others, they need to be mitigated. Fundamental investigation and visualization of how these interactions play out is key to predicting future forces or moments, and to designing appropriate geometries, motion profiles, or control systems to detect and direct the flow field evolution on-the-fly.

What's Inside...

FROM THE DEPARTMENT HEAD



Dear Friends,

Welcome to the summer 2021 edition of the AEM Newsletter. The summer got off to a great start when AEM had an in-person graduation ceremony for the Class of 2021. We are similarly excited for the next academic year, especially with the expectation of seeing students, colleagues and friends in person again.

I am pleased that this group will include our two newest faculty members, Kirsten Strandjord and Melissa Green, who will join the Department this fall. Strandjord is an expert in urban GPS, and joins AEM after receiving her Ph.D., and a subsequent post-doc at the University of Colorado at Boulder. Green is an expert in experimental fluid dynamics with a strong dose of computational expertise as well. She received her Ph.D. at Princeton and started her faculty career at Syracuse University. Strandjord and Green bring not only their research expertise to AEM, but also a strong commitment to teaching and undergraduate and graduate mentoring.

We also celebrate the achievements of our current faculty. Among these are Professor Maziar Hemati's promotion to Associate Professor with tenure, Professor Demoz Gebre-Egziabher's election as a fellow of the Institute of Navigation, and Professor Ryan Caverly's DEPSCoR award from the Department of Defense. Notable research accomplishments include work on a new NASA initiative by Professors Graham Candler, Tom Schwartzentruber and Joe Nichols, and Professor Richard James's research with Professor Bharat Jalan of CEMS on using phase transformations to develop ground-breaking new materials.

AEM students have proven to be equally amazing. Graduate student Jonathan Smith received a NSF Graduate Research Fellowship to support his work with Professors Hemati and Candler. Senior Nathan Pharis was awarded an Astronaut Scholarship from the Astronaut Scholarship Foundation. Nathan has also been involved with research with Professors Flaten and Candler. The University of Minnesota Rocket Team won the 2021 Virtual Spaceport America Cup, while the Alphadrone team won the inaugural Minnesota State Collegiate Drone Sports Championship. I am in awe of the performance and resilience of all our faculty, students and staff over the past year. It is a honor to be a part of it.

It is also a privilege to be a part of the broader AEM community of alumni and friends. As you can see by the stories in this newsletter, your support allows us to engage in innovative research, support phenomenal students and student teams, and to advance our mission by addressing pressing issues in aerospace engineering through innovative and inclusive research and teaching. Thank you!

Be well,

Perry

Did you know we're on Twitter, Facebook, & Instagram?
Visit **cse.umn.edu/aem** for more information.

Professor Maziar Hemati Promoted

We are pleased to report the promotion of Professor Maziar Hemati from Assistant Professor to Associate Professor, effective beginning of Fall Semester 2021.

Hemati earned his Ph.D. in Mechanical Engineering from the University of California, Los Angeles in 2013. Prior to joining the university in 2015, Professor Hemati held positions including Post-Doctoral Research Associate in the Department of Mechanical and Aerospace Engineering at Princeton University, Graduate Researcher in the

Simulations of Flow Physics and Acoustics Laboratory at the University of California, Los Angeles, Advanced Algorithms Engineer at SySense, Inc., Associate Guidance, Navigation, and Control (GNC) Engineer at the Aerospace Corporation, and Associate Engineer at Northrop Grumman Marine Systems.

Professor Hemati's research aims to develop efficient and reliable strategies for the modeling, analysis, and control of fluid flows that arise in various engineering applications. Hemati's research program combines theory, computation, and experiments to advance the state-of-the-art in flow control technologies. Current projects include turbulent transition delay for drag reduction in shear flows; multi-fidelity sensor fusion for advanced turbulent flow diagnostics; aerodynamic separation control for enhanced flight performance and maneuverability; and modeling and control of hypersonic flight systems.

Professor Demoz Gebre-Egziabher elected to Institute of Navigation 2021 Fellow Membership

The Institute of Navigation (ION) announced that Professor Demoz Gebre-Egziabher has been elected to Fellow during the ION International Technical Meeting (ITM) and Precise Time and Time Interval Systems and Applications (PTTI) VIRTUAL meeting held January 25-28, 2021. Gebre-Egziabher was recognized for his contributions in the development and application of multi-sensor integration supporting UAVs and safety of life applications.

Election to Fellow recognizes sustained professional accomplishments that have significantly contributed to the advancement of the arts and sciences of Positioning, Navigation and/or Timing (PNT) in the areas of technology, management, practice or teaching and a demonstrated and sustained impact on the PNT community. Fellows have maintained an observable presence in the ION community over the long term, including contributions to ION programs and publications.

Gebre-Egziabher has made outstanding contributions in the fields of multi-sensor integration and stochastic modelling of their associated error sources. He has incorporated disparate signals from different sensors in order to allow for graceful degradation and recovery from GNSS interruptions. His work further incorporates detailed characterization of errors to support integrity analysis and sophisticated algorithms to extract maximum information from the available data.

Gebre-Egziabher's current area of research is in navigation, guidance and control of aerospace vehicles, with a focus on the application of estimation theory to the development of algorithms and design methodologies to optimally fuse the information from multiple sensors and systems. One of the challenges his group addresses when dealing with problems for aerospace applications, or other safety and liability critical operations, is being able to precisely quantify (in statistical terms) the level of reliability of the algorithms and systems. Examples of the engineering application of his work are in the developmental attitude determination and high-accuracy navigation systems for spacecraft, aircraft and UAVs as well as evaluation operations of small autonomous aerial vehicles in the national airspace system. His group's UAV and Small Satellite Laboratories supports education by bringing real-world aerospace development and flight-testing experiences into undergraduate- and graduate-level courses and leading-edge aerospace research.

Ryan Caverly Receives DEPSCoR Award

University of Minnesota (UMN) Aerospace Engineering and Mechanics (AEM) Professor Ryan Caverly received a Department of Defense (DoD) Defense Established Program to Stimulate Competitive Research (DEPSCoR) award. UMN AEM Professor Maziar Hemati will be serving as co-PI/mentor on the project. Their team will receive up to $600,000 over a three-year period of performance to pursue science and engineering research in areas relevant to DoD initiatives supporting the National Defense Strategy.

DEPSCoR is a congressionally mandated, capacity building program that is designed to strengthen the basic research infrastructure at institutions of higher education in underutilized states and territories. The program is managed by the Directorate of Defense Research and Engineering for Research and Technology (DDRE(R&T)) within the Office of the Under Secretary of Defense for Research and Engineering.

Caverly's project "On-the-Fly Flight Test Maneuver Optimization and Nonlinear Modeling of Hypersonic Systems" was chosen from over 160 white papers, from which subject-matter experts in the military services selected the final 17 collaborative teams. The goal of the project is to develop a unified testing and evaluation approach for hypersonic flight systems that involves optimizing both the design of flight test maneuvers and the extraction of reliable control-oriented models.

High-precision control of a hypersonic flight system traveling at speeds higher than Mach 5 requires knowledge of an accurate control-oriented flight model. Numerical simulations can provide insight into the flight model, but ultimately, flight tests are needed to identify the complex dynamics of hypersonic flight. Unfortunately, hypersonic flight test opportunities are limited, typically short in duration, and accompanied by substantial risk.

Caverly and Hemati plan to develop a framework that optimizes flight test maneuvers and extracts nonlinear models relevant for high-precision control of hypersonic systems, while guaranteeing airworthiness during testing. They will make use of mathematical techniques from data-driven dynamical systems and robust control theory to perform nonlinear modeling, uncertainty quantification, and stability analysis. The research team will also investigate an "on the fly" flight testing approach, which will involve recursively refining the flight model with incoming data and re-optimizing the flight test maneuvers during the flight test itself.

Caverly says, "This project brings together the complementary expertise that Maziar's group has in the areas of data-driven modeling and analysis, and my group's focus on optimal and robust control theory. Combining these capabilities will allow us to develop a unified approach to flight test maneuver optimization and modeling."

Advanced Computational Center for Entry System Simulation

AEM Professors Graham Candler, Tom Schwartzentruber, Joe Nichols and Math Professor Bernardo Cockburn are part of the $15 million multi-institutional leadership team on a newly funded NASA Space and Technology Research Institute initiative named Advanced Computational Center for Entry System Simulation, or ACCESS.

The ACCESS institute will advance the analysis and design of NASA entry systems by developing a fully integrated, interdisciplinary simulation capability. Entry, descent, and landing technologies must continue to improve to meet the challenges of placing large payloads on other worlds, such as Mars. Accurate modeling and simulation of atmospheric entry systems are critical for the design and planning of these missions.

ACCESS will focus on thermal protection systems, which protect spacecraft from aerodynamic heating, as well as prediction of the extreme environments experienced during entry. It will develop game-changing capabilities through the use of high-fidelity, validated physics models. This advancement will be enabled by innovative numerical algorithms, high- performance computing, and uncertainty quantification methods, with the goal of enabling computational entry system reliability assessments.

Jonathan Smith Receives NSF Graduate Research Fellowship

Aerospace Engineering and Mechanics graduate student, Jonathan Smith, has been named a National Science Foundation (NSF) Graduate Research Fellow. Smith will receive a five-year fellowship period and three- year annual stipend of $34,000 along with a $12,000 cost of education allowance.

Smith is a first year PhD Student in Aerospace Engineering and Mechanics studying fluids and controls. He graduated from Washington University in St. Louis with a Bachelor's in Mechanical Engineering and minors in Aerospace Engineering & Materials Science. He is working with AEM Professors Maziar Hemati and Graham Candler on analyzing CFD simulations of transitional hypersonic flow, with plans to develop an input-output framework for predicting transition to turbulence in hypersonic flows.

Ph.D. Student, Ali Buyukkocak, Receives 2021 MnDRIVE Assistantship

Aerospace Engineering and Mechanics graduate student, Ali Tevfik Buyukkocak, has been awarded a 2021 MnDRIVE PhD Graduate Assistantship. The fellowship supports UMN PhD candidates pursuing research at the intersection of informatics and any of the five MnDRIVE areas: Robotics, Sensors and Advanced Manufacturing. Global Food Ventures. Advancing Industry, Conserving Our Environment, Discoveries and Treatments for Brain Conditions, and Cancer Clinical Trials

Buyukkocak, who received his B.S. and M.S. in Aerospace Engineering from Middle East Technical University in his hometown of Ankara, Turkey, has been working with AEM Professor Derya Aksaray on autonomous robots. These robots are being used in an increasing number of applications in recent years. Even so, developing control strategies for groups of robots working together could greatly expand their capabilities.

2020 John and Jane Dunning Copper Fellows

We are proud to announce Xiaoshan Lin, Niles Ribeiro, and Vinh Le Nguyen as the recipients of the 2021 John and Jane Dunning Copper Fellowship.

Xiaoshan Lin received his Bachelors in Mechanical Engineering at Shanghai Jiao Tong University before joining the department in 2020 to pursue a Ph.D. in the Aerospace Engineering and Mechanics department. Lin works with Professor Derya Aksaray on control and planning for multi-robot systems.

Niles Ribeiro received a Bachelors in Mechanical Engineering at Johns Hopkins University and before joining the department in Fall 2020. Ribeiro works with Professor Graham Candler in the Computational Hypersonics Research Lab. Ribeiro works with Professor Graham Candler in the Computational Hypersonics Research Lab on modeling turbulence within Hypersonic flows. Ribeiro has been interested in Aerospace Engineering since a young age but really became motivated during his undergraduate years. He says, "…my interests in Computational Fluid Dynamics took off in my undergraduate studies, and motivated me to pursue more specialized courses and research. This trajectory brought me to UMN to research hypersonic flows using the cutting-edge computational tools developed here."

Vinh Le Nguyen is a native Minnesotan and did his undergraduate studies in AEM before joining the graduate program. He works with Professor Ryan Caverly on research in robotics, which he started as an undergraduate. In the future, he would like to complete his PhD then pursue a career that is research based.

AEM Student Receives Prestigious Astronaut Scholarship

Aerospace Engineering and Mechanics student Nathan Pharis has received a scholarship from the Astronaut Scholarship Foundation (ASF) for the 2021-2022 academic year. The prestigious, competitive scholarship, initiated by the Mercury-7 astronauts, is awarded annually to outstanding sophomores and juniors who intend to pursue research-oriented careers in mathematics, engineering, and the natural and applied sciences.

Pharis has been actively involved in research in AEM, where he studies micron-sized particles with Professors James Flaten, Associate Director of the MN Space Grant Consortium, and Graham Candler, McKnight Presidential Chair. Pharis' current plans are to complete graduate degrees with focus on aerospace control systems for spacecraft. His long-term goal is become a professor so he can continue to do research while also teaching the next generation of students.

AEM Student Elected to Participate in MSROP

Aerospace Engineering and Mechanics senior, Samir Patel, has received a $4,000 stipend for personal and research expenses from the Multicultural Summer Research Opportunities Program. Patel will is also working through a research stipend assigned by his faculty mentor, Ryan Caverly.

Patel's research involves implementing constrained attitude parameterizations to calculate the position and orientation of a payload on a cable-driven robot system. The Aerospace, Robotics, Dynamics, and Control (ARDC) Lab has used unconstrained parameterizations to calculate the position and orientation of a payload. He and Professor Caverly are taking this a step further by making use of constrained parameterizations, such as Axis-Angle Parameters and Quaternions, which they believe can result in measurements that are more accurate. The goal of this research is to determine whether the constrained attitude parameterizations are more accurate at measuring the payload's position and orientation than the unconstrained attitude parameterizations.

Patel notes that despite the challenges of COVID-19, he has been able to focus on his research in part due to the fact he previously worked with Professor Caverly and was able to familiarize himself with the project before going virtual.

AEM Student Shoots for the Stars

When eight-year-old Robert Halverson's mother asked him what he wanted to be when he grew up, he always said, "Bob the Builder." Since being a cartoon character wasn't exactly in the cards, he eventually settled on "astronaut." Now, Halverson is a senior studying aerospace engineering in the College of Science and Engineering—and he's held on tightly to that dream.

"I've always enjoyed looking up to the sky and looking up at the stars and seeing what's out there," said Halverson, who was born in Minnesota but later moved to Arkansas.

Halverson is the first in his family to attend college. He is spending the summer in Colorado for a summer internship with Blue Canyon Technologies, a small satellite technology company. After that, he plans to pursue a master's degree in aerospace engineering at the University of Minnesota. Then, onto NASA, he hopes.

"It felt like a big thing for me, going to college and especially getting a degree that's basically shorthand for rocket science," he said. "You get to work on meaningful projects that have a great impact on humanity, and I figured that's a good way for me to be productive in advancing technology, while waiting on my chance to walk among the stars, as they say."

To say that Halverson has made the most of his time as a Gopher is an understatement. In addition to taking a full load of classes and doing research with one of his professors, he works as a peer assistant for the

CSE Career Center; plays trombone in the North Star Philharmonia campus orchestra; and is a member of the UMN Rocket Team's propulsion sub- team; and served as president of the UMN chapter of the American Institute of Aeronautics and Astronautics (AIAA). Oh, and he teaches taekwondo.

Being an effective leader is another tangible he's taking away from his research experience, with AEM Professor Ryan Caverly and his graduate students.

"My viewpoint of a leader is it's not someone who's above anyone," Halverson said. "It's someone who helps their group advance and sets others up for success. Being the mentee in this research experience certainly has shown me that anyone can be a leader and you don't have to put a title on it. Whether it's giving or receiving, there are so many opportunities [at the U of M] to learn from other people and to help other people, whether it's in academics, career, or just life."

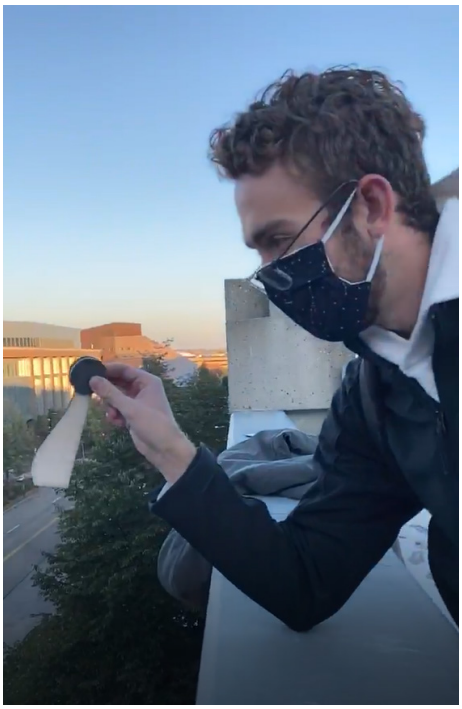
He hopes to continue being involved in leadership after graduation. And no matter what, Halverson wants to keep doing meaningful work related to spaceflight.

"With the way that the world has changed in the last 50 years since we've been to the moon, imagine how much that can change when we go to Mars," he said. "And there are a lot of problems that need to be solved along the way, and I want to contribute to those."

CanSat Team Places 17th Internationally

We are pleased to report that AEM's CanSat team has placed 17th internationally at the annual American Astronautical Society CanSat competition. 42 teams competed from all over the world including from Mexico, India, Turkey, and the United States.

The annual competition is open to teams from universities and colleges. Teams must be able to design and build a space system, following the approved competition guide, and then compete against each at the end of two semesters to determine the winners. Rockets are provided but teams are responsible for funding the construction of their CanSat and all travel/lodging expenses. The competition is unique among space related competitions in that it gives students the satisfaction of being involved with the end-to-end life cycle of a complex engineering project, from conceptual design, through integration and test, actual operation of the system and concluding with a post-mission summary and debrief.



For 2021, the CanSat competition asked teams to design a 5" diameter Canister Satellite that could be deployed from a rocket at roughly 700m above ground level and immediately deploy a parachute. Upon descent at altitudes of 500m and 400m, the Canister would release two "maple seed" payloads that would autorotate (and therefore slow their own descent). The payloads and Canister would collect data from on-board sensors and transmit the data through a pre-designated telemetry architecture to a ground station.

Because of COVID-19, the competition was held virtually this year. The team completed a virtual demonstration of simulated flight data to the Canister via the ground station in order to see how it performed. The restrictions on going to the lab forced the team to design and built components for CanSat from home, and meet virtually on a weekly basis until they were allowed to meet on campus. Once on campus, the team worked in pairs during limited occupancy in the labs before finally working as a team on system integration and testing once occupancy restrictions were relaxed.

As the entire team graduated in May, the current team along with AIAA leadership is working to find and recruit new members and a team lead. Anyone interested in joining CanSat can contact AIAA for more information at aiaa.aem.umn.edu.

AEM 4333 SENIOR DESIGN - Spring 2021

While all the Senior Design teams faced challenges this past year owing limited access to campus, machine shops, and labs, they also received a unique and valuable experience in project risk management and re-scoping to meet new requirements and new realities. Despite many events or projects being virtual, the senior teams tackled every challenge head on.

Four Senior Design teams that proceeded into the build and test phases of their projects. Teams for the CanSat Competition, rocket powered UAS Interceptor, disposable UAV, and a VTOL land survey UAV performed successful builds and tests.

CanSat

The CanSat Competition, sponsored by the American Astronautical Society, is an annual in-person competition allowing students the opportunity to design, build, and test a deployed rocket payload. Last year the competition was canceled as result of the COVID-19 pandemic. This year the competition was modified to be performed remotely with a series of prescribed demonstrations conducted with the competition judges via a video conference.

Rocket Team prepping for flight

UAV Survey aircraft

During Fall 2020 the CanSat team designed their rocket payload consisting of a deployed container and two additional autorotating maple seed payloads. Three independent science platforms were designed to gather atmospheric data, with the two samara wings relaying their measurements through the central container platform, which in turn provided telemetry to a ground control station.

Rocket Team

The rocket powered UAS interceptor team, sponsored by Northrop Grumman designed a rocket with flight path control. During the design and test phase of the project the team focused on validating that the fundamental aspects of rocket flight path control and performance were accurately predicted. A proof-of- concept rocket with actuating control surfaces, dedicated sensors, and data logging was purpose-designed during the Fall semester.

In the spring, the rocket was built and successfully launched and recovered with the help of Tripoli MN (http://www.tripolimn.org/). The rocket team was able to observe rocket flight path actuation and measure rocket performance near their analytic predictions.

UAV Teams

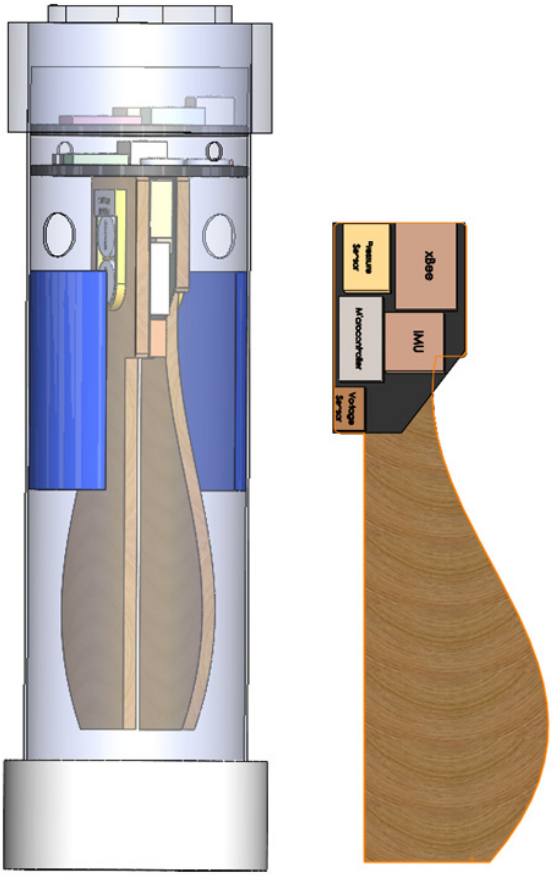
Two UAV design teams built and tested UAVs that addressed particular challenges encountered during small UAV operations for land surveying. One team designed

a UAV with a focus on enabling airframe construction in underdeveloped regions of the world. The intent was to design an inexpensive and easily produced airframe that could houses a small modular core flight system. The airframe cost and construction was such that the airframe itself could be considered disposable.

The disposable UAV team successfully flight tested their prototype aircraft validating basic aircraft functionality and estimating as-built aircraft performance characteristics.

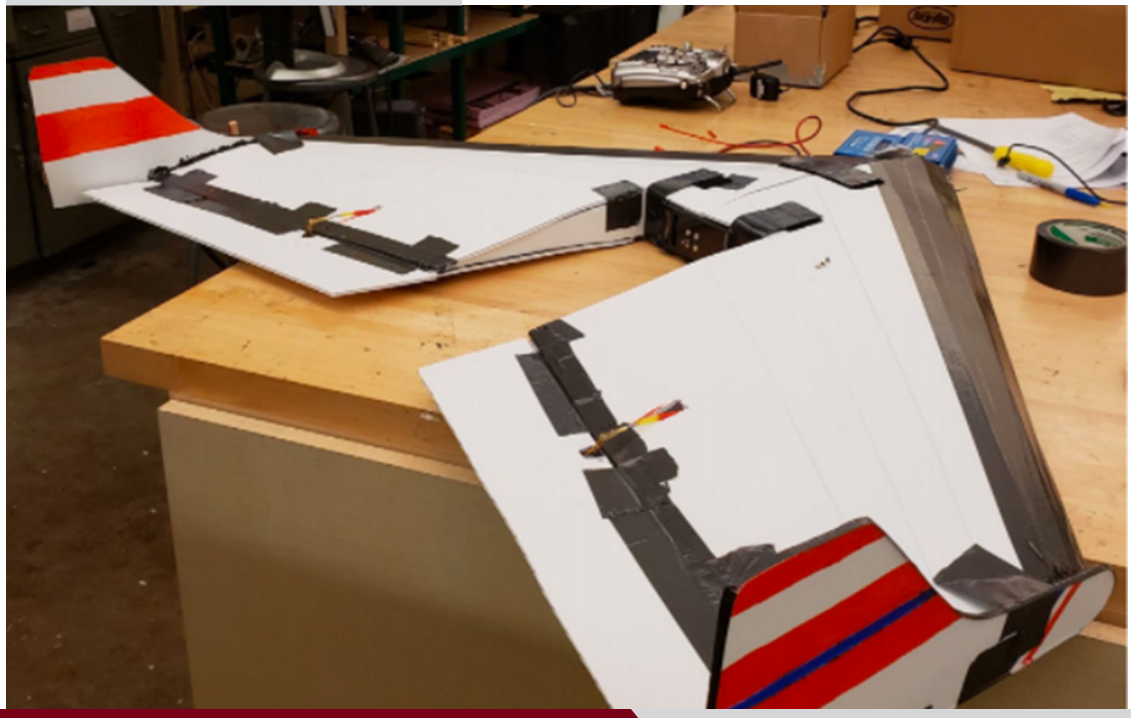
The second UAV team designed a survey aircraft with vertical takeoff and landing capabilities to allow operations in forested areas with limited space for launching and landing a traditional fixed wing UAV. For takeoff and landing the aircraft operates as a tri-copter with tilting wing rotors. Once airborne the aircraft transitions to forward flight by tilting the wing rotors forward.

During Spring semester the team was able to build a prototype aircraft and demonstrate vertical takeoff and landing of the aircraft in flight. Aircraft performance in the forward flight configuration was measured in order to validate the analytic prediction used during design.



CanSat Propeller design

Disposable UAV prototype

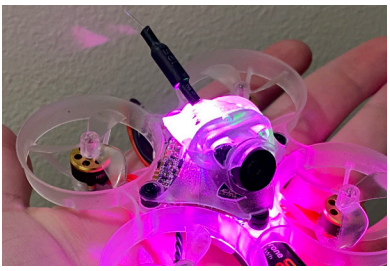


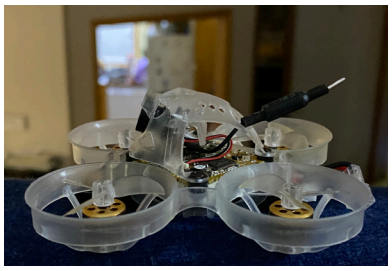
Alphadrone Wins with a Clean Sweep

The drone team from the University of Minnesota College of Science and Engineering Student team, Alphadrone, raced their way to victory at the inaugural Minnesota State Collegiate Drone Sports Championship in Bloomington, Minnesota in both the Individual Racing and the Team Racing category.

The championship was held by RdyTechGo, a first-of-its-kind venue for competitive STEM and tech sports, at Mall of America. RdyTechGo was created by Hydra FPV who also hosts the Youth Drone Sports Championships (YDSC) at both college and high school levels. Hydra FPV has co-developed an educational Build-and-Race FPV drone kit that would offer schools hardware and curriculum assistance.

In addition to the team event, Alphadrone's Samuel Westlake (team leader) and Clayton Horstman-Olson both competed individually. Drone pilots are typically given code names. Westlake was known as NautilusFPV and Horstman-Olson as Speedy.





Students have been racing virtually since COVID-19, bringing home controllers used to pilot drones and plugging them in virtually. This competition, however, was one of the first in-person events held this year. The team won first place, while University of Minnesota Duluth achieved second, and St. Cloud State took third. In the individual competition, Horstman-Olson won the individual collegiate state championship as well as the international collegiate simulator championship completing his own sweep at the Collegiate Drone Sports Championship (CDSC) level.

Westlake said, "We feel great about our win in the State Team competition and look forward to seeing more teams next year. The biggest challenge was definitely time. We had very little time to practice the track before we raced on it and the other teams were very experienced on it already. We were able to fly consistently enough to make up for our lack of flat-out speed and that consistency made all the difference in the finals."

Drone racing is a unique sport where pilots wear special headsets that connect to the drones, allowing the pilots to fly as if they were inside the drone. Pilots race through technical, 3-dimensional tracks, going through gates, tunnels and weaving around flags. Outdoor racing drones can go as fast as 100mph on the open straights of a track.

Indoor drones aren't quite as fast and have covered blades that help prevent injury if they bump into people. Marty Wetherall, CEO of Hydra FPV, noted that "We call it drone sports because it's more than just racing. We build, program, and design the drones. It encompasses all aspects of the drones."

Westlake, a senior in Mechanical Engineering, has been flying and building drones since before attending the University of Minnesota. He took his passion for the sport and formed the University's first drone racing team. "I love the feeling of flying in the goggles that I wear and I want to give other people that chance as well. Because there were no existing drone racing teams on campus, I reached out to AIAA and was able to create a subteam [Alphadrone] under their direction."

Students interested in joining Alphadrone can contact Samuel Westlake at westl255@umn.edu. Colleges and universities interested in forming teams and competing can contact Marty Wetherall, CEO of Hydra FPV for more information at 952-270-7922 or email marty@youthdronesports.org.

Rocket Team Wins 2021 Virtual Spaceport America Cup

Spaceport America and the Experimental Sounding Rocket Association (ESRA) have announced that the University of Minnesota, Twin Cities, has been selected as the winner of the 2021 Virtual Spaceport America Cup. The team won not only in their category, 30,000ft Solid SRAD Motor, but took first place in the overall competition.

Seventy-five teams from 16 different countries competed during the three-day, online event that occurred from June 18-20. The virtual competition allowed university student teams to submit rocket designs for evaluation and included technical presentations and forums, keynote addresses from aerospace industry leaders and rocket safety training. Competitors also had the opportunity to meet with sponsors and exhibitors to learn more about aerospace career pathways and recruitment.

For the 30,000ft solid SRAD motor category, the team designed a rocket system capable of carrying a payload of a mass of at least 4kg to an altitude of 30,000ft above ground level using a Student Research and Developed Solid Propellant Motor. The team had to also ensure that the rocket had robust recovery and tracking systems and also submitted a nearly 100-page technical report and 15 minute video documenting the rocket system, which included an extended abstract and slide deck covering a chosen part of the rocket. They chose to submit the abstract and slide deck covering their Universal Flight Computer, which is a modular, custom avionics bay designed to fit in the nose cone. The team was selected from 20 teams to present (which was on the Universal Flight Computer) and participated in a 15 minute Q&A session. Launching a rocket was not required for the competition and did not factor into scoring, but the UMN group did so anyway in order to get team members launch experience and to see how their design fared in flight conditions.

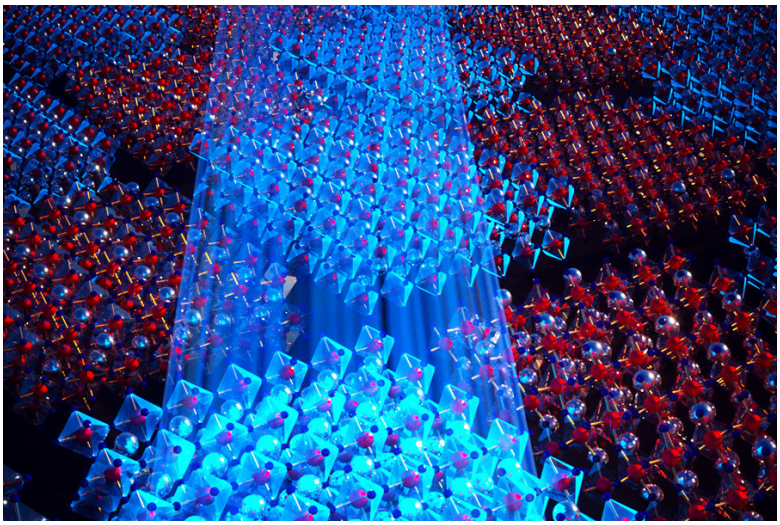
"Congratulations to the University of Minnesota, Twin Cities and all the other teams that competed in the 2021 Virtual Spaceport America Cup," said Spaceport America Executive Director, Scott McLaughlin. "The event turnout has been incredible, and the caliber of the design and innovation has really impressed us. We look forward to welcoming the teams back to New Mexico in 2022."
The team has been able to work on designing and building though in limited capacity because of COVID-19. The rocket designed for competition and the rocket flown for the test launch differed slightly due to FAA regulations limiting maximum altitude to 20,000ft at the North Branch, MN launch site. The test launch rocket was slightly more than 12 ft. tall, 6 inches in diameter, weighed 123 lb., had a solid propellant motor configured to hit an altitude of about 18,000 ft., had an aluminum fin can with 4 fins, and contained a payload, a triple redundant deployment avionics system for a dual-deploy parachute system, and custom Universal Flight Computer.

In the summer, the team plans to continue designing and building their High Altitude rocket with the hopes of competing at a different event in Nevada in September with a smaller group. At the same time, the group also hopes to improve on a few aspects as a team.

The team is looking into building a rocket with a larger diameter next year, making fins from carbon fiber, and designing a new solid propellant. Technically, they would like to improve the robustness of recovery and payload systems and the reliability their telemetry systems. As a team, they hope to build their outreach program and conduct more events with local schools and organizations. They are also recruiting with special emphasis on continuing to limit disparities in diversity that often affect college engineering teams.

Researchers develop new one-step process for creating self-assembled metamaterials

Discovery is big step forward in creating new materials used in a variety of applications including optical devices and sensors.



While studying a thin-film material called strontium stannate (SrSnO3), University of Minnesota researchers noticed the surprising formation of checkerboard patterns at the nano scale similar to structures fabricated in costly, multi-step processes. Their results show the realistic possibility of designing similar self-assembled structures with wide applications in materials for electronics and optical devices. Credit: Jalan Group, University of Minnesota

A team led by University of Minnesota Twin Cities researchers including AEM Professor Richard James has discovered a groundbreaking one-step process for creating materials with unique properties, called metamaterials. Their results show the realistic possibility of designing similar self-assembled structures with the potential of creating "built-to-order" nanostructures for wide application in electronics and optical devices.

The research was published and featured on the cover of Nano Letters, a peer-reviewed scientific journal published by the American Chemical Society.

In general, metamaterials are materials made in the lab to provide specific physical, chemical, electrical, and optical properties otherwise impossible to find in naturally occurring materials. These materials can have unique properties which make them ideal for a variety of applications from optical filters and medical devices to aircraft soundproofing and infrastructure monitoring. Usually these nano-scale materials are painstakingly produced in a specialized clean room environment over days and weeks in a multi-step fabrication process.

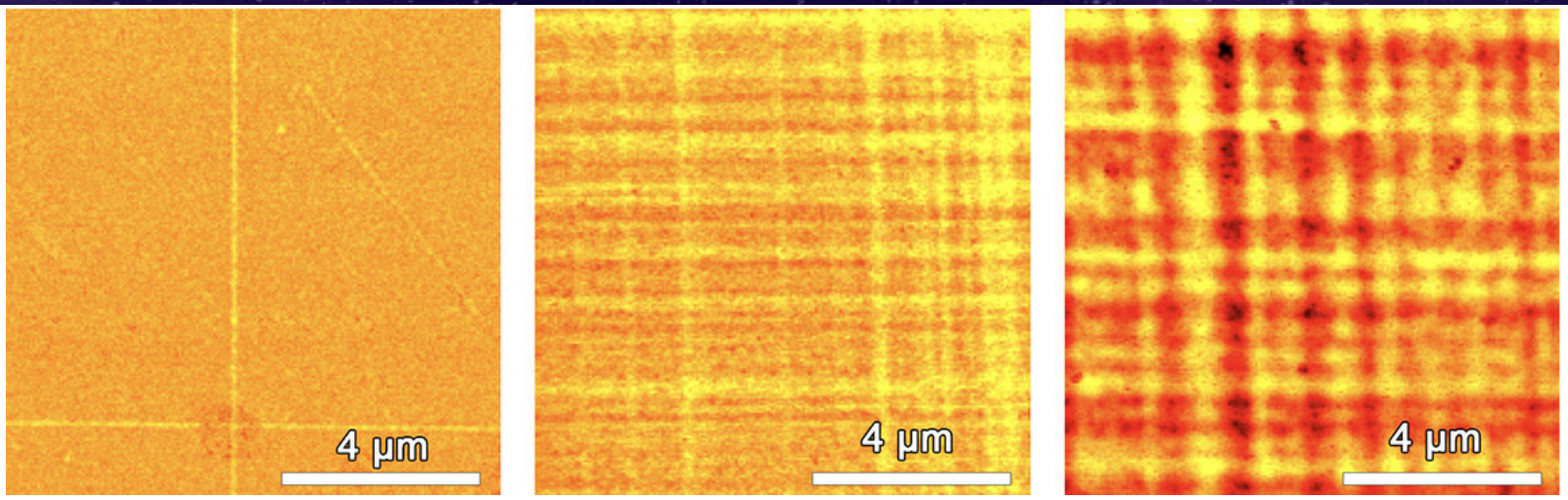
In this new research, a University of Minnesota team was studying a thin-film material called strontium stannate or SrSnO3. During their research, they noticed the surprising formation of checkerboard patterns at the nano scale similar to the metamaterial structures fabricated in the costly, multistep process.

"At first we thought this must be a mistake, but soon realized that the periodic pattern is a mixture of two phases of the same material with different crystal structures" said Bharat Jalan, the lead author of the study and an expert in material synthesis who is the Shell Chair in the University of Minnesota's Department of Chemical Engineering and Materials Science. "After consulting with colleagues at the University of Minnesota, University of Georgia, and City University of New York, we realized that we may have discovered something quite special that can potentially have some unique applications."

The material had spontaneously organized into an ordered structure as it changed from one phase to another. During what is called a "first-order structural phase transition" process, the material moved into a mixed-phase in which some parts of the system completed the transition and others did not.

"These nanoscale periodic patterns are the direct consequence of the first-order structural phase transition in this material," said University of Minnesota aerospace engineering and mechanics Professor Richard James, a co-author of the study and a Distinguished McKnight University Professor. "For the first time, our work enables a host of possibilities for utilizing reversible structural phase transformations with nanoelectronic and photonic systems."

In fact, the team demonstrated a process for the first-ever, self-assembled, tunable nanostructure to create metamaterials in just one step. The researchers were able to tune the ability to store electrical charge property within a single film using temperature and laser wavelength. They effectively created a variable photonic crystal material with 99 percent efficiency.



Using high-resolution electron microscopes, the researchers confirmed the unique structure of the material.

"We observed that the boundaries between these crystallographic phases were sharply defined at the atomic scale, which is remarkable for a self-assembled process," said Professor Andre Mkhoyan, a co-author of the study, an expert in advanced electron microscopy, and the Ray D. and Mary T. Johnson/Mayon Plastics Chair in the Department of Chemical Engineering and Materials Science at the University of Minnesota.

The researchers are now looking to future applications for their discovery in optical and electronic devices.

"When we started this research, we never thought about these applications. We were driven by the fundamental study of the physics of the material," Jalan said. "Now, all of a sudden, we seem to have opened up a completely new area of research, which is driven by the possibility of many new and exciting applications."

In addition to Jalan, James and Mkhoyan, the team included University of Minnesota researchers Abhinav Prakash, Ashley Bucsek, Tianqi Wang, Tristan K. Truttmann, Hwanhui Yun; University of Georgia researchers Alireza Fali and Yohannes Abate; City University of New York researchers Michele Cotrufo and Andrea Alù; and Argonne National Laboratory researchers Jong-Woo Kim and Philip J. Ryan.

The research was primarily funded by the National Science Foundation (NSF), and the Air Force Office of Scientific Research (AFOSR) with additional support from the University of Minnesota Institute on the Environment, Norwegian Centennial Chair Program, and two Vannevar Bush Faculty Fellowships. Work at the University of Minnesota involving thin film characterization was supported by the U.S. Department of Energy. Parts of the research were carried out at the Minnesota Nano Center and Characterization Facility at the University of Minnesota, funded in part by the National Science Foundation. Additional work was completed at the Advanced Photon Source, an Office of Science User Facility operated for the U.S. Department of Energy Office of Science by Argonne National Laboratory.

To read the full research paper entitled "Self-Assembled Periodic Nanostructures Using Martensitic Phase Transformations" visit the ACS Publications website at z.umn.edu/6y15.

Bharat Jalan
Associate Professor, Chemical Engineering and Material Science, University of Minnesota

Richard D. James
Distinguished McKnight University Professor, Aerospace Engineering and Mechanics, University of Minnesota

Congratulations Graduates!

BAEM recipients:

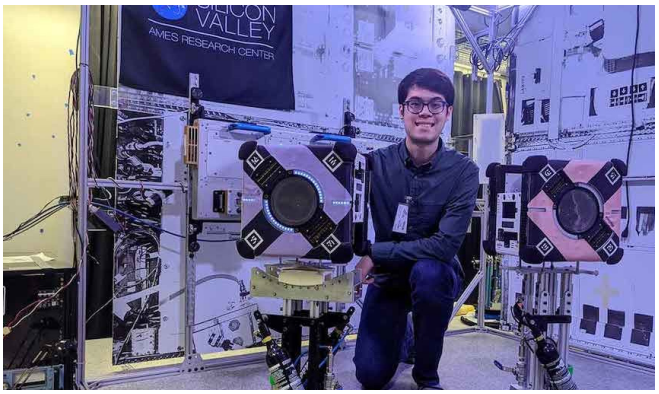
Andersen, Taylor P
Barthelemy, Kimberly
Baum, Alex J
Berezin, Michael
Bombeck, Daniel
Brown, Jacob J
Buesing, Aidan
Butzer, Emma
Caravantes, Michael
Carpenter-Graffy, Dina
Chapman, Jacob Brian
Collins, Patrick James
Conlin, Nicholas Kallin
Davis, Rachel
Dorn, Timothy
Douglas, Joel Patrick
Downs, John Steven
Dunham, Campbell
Dunham, Scott Richard
Fehr, Thomas Matthew
Friess, Jacob John
Griffitt, Sylvia Louisa
Halverson, Robert D
Higgins, Elliott Michael
Hirsch, Samuel James
Holcomb, Trevor Jon
Horejsi, Ryan T
Huynh, Lin Truong Da
Jing, Yifan
Kaeppe, Rayna Lauren
Kinattumkara, Shreyans
Klopfenstein, Caleb
Kramer, Aaron James
Kost, David
Lenz, Emma Grace
Liu, Lengji
Loomis, Veronica Mary
Lorentzen, Jack E
Lundgren, Kathryn
Luppi, Michael P
Mcgee, Devin Anthony
Meyer, Jacob Joseph
Mitchell, Steele Hunter
Mollenhauer, Alec
Mottishaw, Whitney
Moynihan, Joseph
Nelson, Robert
Noma, Nathan K
Omotoyinbo, Adeyinka
Orpen, Kevin P
Peters, Michael Scott
Polfliet, Machlen R
Pudwill, Brady Michael
Reilly, Hannah
Rios, Marcus Adrian
Rivera, Noah Anson
Rowell, Donald
Rossini, William S
Rustad, Charles
Siekmeier, Kaleb A
Siles Garner, Jonathan
Simmons, Cody W
Stube, Ryan
Syke, Ellis David
Tungate, Evan Taylor
Unruh, Albert
Van Gerpen, Andrew
Vedvik, Sophia Rose
Wagner, Jacob
Wiehle, Caden C
Willis, Benjamin J
Wipf, Kyle Lee
Wong, Tabitha
Zarling, Andrew T
Zeller, Emma Frances
Zhou, Xuanchen

AEM Masters and PhD recipients:

Alame, Karim
Allen, Nia D
Anantharamu, Sreevatsa
Asarkaya, Ahmet Semi
Baker, Lucia Jane
Bhatt, Mrugank
Dwivedi, Anubhav
Fakhreddine, Ali
Fong, Kee Onn
Ghazanfar, Syed Anas
Gu, Hanlin
Houston, Mary
Hoyt, Jordan
Dunn
Ichinose, Ryan
Johnston, Zachary
Koenig, Michael
Kroll, Thomas
Kumar, Dharam-veer
Laughlin, Kail P
Madabhushi, Aditya
Medan, George
Merin, Merin
Morse, Nicholas
Mrema, Honest
Paul, Sagnik
Petersen, Alec
Peterson, Ryan J
Reinert, John
Shen, Ping-Yen
Siew, Peng Mun
Sun, Ke
Trevino, Loretta
Vitral Freigedo Rodrigues, Edu-ardo
Venkataraman, Harish Kumaar
Wang, Mengying
Yao, Huaijin

Congratulations to this year's BAEM, MS, and PhD graduates on all of their accomplishments!

Robotics in Space



Bryce Doerr has always felt inspired by the achievements of the United States space program. Doerr knew he wanted to contribute to the development of technology to help progress humanity forward through the unknown.

Pursuing his passion, Doerr graduated from the University of Minnesota Twin Cities in 2019 with his doctoral degree in aerospace engineering and mechanics. In October 2019, Doerr joined the Intelligence Community (IC) Postdoctoral Research Fellowship Program and began conducting research on space robotics. The IC Postdoctoral Program is administered by the Oak Ridge Institute for Science and Education (ORISE). The program offers scientists and engineers from a wide variety of disciplines unique opportunities to conduct research relevant to the Intelligence Community. When his fellowship concludes, Doerr plans to continue his research at the NASA Goddard Flight Research Center Attitude Control Systems Engineering Branch.

“My goal is to develop cutting-edge research in new technologies for new space missions,” he said. “This includes areas of control of large collaborative swarms and on-orbit assembly, as well as the combination of the two. By having the flexibility of working for a government agency, I can produce work that aligns with both my and the public’s interest."

Mars Mission

On Feb. 18, NASA’s Mars Perseverance rover made its final descent, and Andy Vano sent a quick text to his grandchildren: “Today is a historic day for the mission to Mars. The Perseverance rover has landed safely.”

From 1963 to 1973, Vano was an aerospace engineer at the NASA Flight Research Center at the Edwards Air Force Base in California. While at the NASA Flight Center, Vano worked on many different projects, including the North American X-15, a hypersonic rocket-powered aircraft and build the Lunar Landing Research Vehicle.

During his time at NASA, while at the research center, he was taking a class at the Jet Propulsion Laboratory. NASA had a program, the Surveyor, from June 1966 through January 1968, that sent seven robotic spacecraft to the surface of the moon. The program was implemented by the Jet Propulsion Laboratory and the Surveyor craft was the first American spacecraft to achieve soft landing on the moon.

After moving back to Minnesota, Vano worked as a professor in the Aerospace Engineering and Mechanics Department. Vano taught AEM’s Capstone design class and ended up receiving a grant from NASA for his design class. His students designed lunar transportation systems for manned missions to Mars and landings on Jupiter. Vano looks back at his NASA days with a great fondness and said that his time there was definitely interesting.

Vano will continue watching the exploration of the Mars Perseverance rover and hopes others do too, as he said it is an exciting part of history.

Original article appeared in Twin Cities Pioneer Press

Senior Exit Survey Results

Each year, graduating seniors complete a 30 question senior exit survey evaluating the AEM program. The survey is intended to touch on student experiences in both lower division and upper division, and to examine student experiences both in and out of the classroom. Last spring, the number of responses was well down from previous years, likely owing to the on-line format brought on by COVID-19. The responses are listed below, with scores ranging from 1 (worst) to 5 (best). Despite the low number of responses, they indicate that AEM students are pleased with their education. Students had especially positive feedback and comments on the required technical courses, the design course, and the accessibility of the faculty. Areas that students indicated could be improved include the laboratory facilities and turn-around time for grading assignments and exams. As in past years, students also wanted more computational tools and resources.

2019-20

Preparation to use engineering tools like CAD: 4.17
Quality of AEM Advising: 4.3
Knowledge of Aerodynamics: 4.77
Knowledge of Aerospace Structures: 4.54
Knowledge of Atmospheric Flight Mechanics: 4.8
Quality of Design Experience: 4.45
Quality of Laboratory Facilities: 3.9

2020-21

Preparation to use engineering tools like CAD: 3.88
Quality of AEM Advising: 4.16
Knowledge of Aerodynamics: 4.68
Knowledge of Aerospace Structures: 4.05
Knowledge of Atmospheric Flight Mechanics: 4.49
Quality of Design Experience: 4.30
Quality of Laboratory Facilities: 3.76

AEM Undergraduate Program Objectives

1. Consistent with the mission of the University of Minnesota, graduates of the BAEM program will be success fully employed in aerospace or other high technology industries.
2. Graduates admitted to graduate level studies in engineering and other professions will obtain an advanced degree.

Outcomes

Upon completion of the AEM degree students will have:

1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
3. An ability to communicate effectively with a range of audiences
4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
5. An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

From the Development Office:

The last 15 months have been an unbelievable challenge for everyone, as we all moved from our regular lives to working, living, and learning virtually. The AEM faculty have been incredibly successful in pivoting from in-person to online classes while continuing to provide our students with a first-rate education as they prepare for their careers. We have been both delighted and humbled by the generosity of our alumni, friends, and donors who have continued to support the department and our students through philanthropic gifts. Your generosity has supported our students, our research, and faculty at the time it was most important.

Thanks to all of you who have kept us moving forward with your gifts. We are grateful for your support and your willingness to inspire others to follow your lead.

Kathy Peters-Martell
Senior Development Officer
College of Science and Engineering

Thanks to the individual and companies listed below for their generous gifts to support of the AEM department and our students. In this extraordinarily challenging time, these gifts to the AEM department were incredibly important to the department, our research, and our students. These are the gifts received July 1, 2020 – June 15, 2021.

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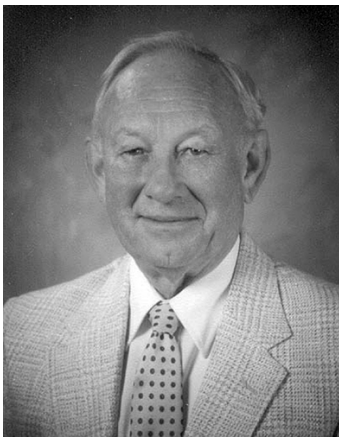
Department Mourns the Loss of Professor Emeritus Jerald Ericksen



Jerald LaVerne Ericksen, Professor Emeritus in the Department of Aerospace Engineering and Mechanics and the School of Mathematics at the University of Minnesota, died June 11, 2021.

Jerry Ericksen was born on December 20, 1924. Ericksen finished his undergraduate studies at the University of Washington in one year and received a bachelor's degree with a major in mathematics and a minor in naval science.He earned a Ph.D. In mathematics at Indiana in 1951. In 1957, he joined the Mechanical Engineering department at Johns Hopkins University, and then moved to the Department of Aerospace Engineering and Mechanics at the University of Minnesota Twin Cities, with a joint appointment in the School of Mathematics, in the early 1980s.

Ericksen was a central figure in the resurgence of interest in continuum mechanics in period from the late 1940s to the early 1970s, along with Ronald Rivlin, Clifford Truesdell and many others. He is particularly well known for formulating the dynamic theory of liquid crystals (with Frank Leslie), for his discovery of the universal deformations of elastic materials (``Ericksen's problem''), and for studies that elucidated the unusual behavior of non-Newtonian fluids. His work could be quite abstract, but it was often intimately related to experimental measurement.

In addition to membership in the National Academy of Engineering, Ericksen was abundantly honored for his contributions, among others, the Bingham medal from the Society of Rheology (1968), the Timoshenko Medal from the American Society of Mechanical Engineers (1979), and the Engineering Science Medal from the Society of Engineering Science (1987), and several honorary doctorates. Ericksen said, "While the honors are very nice in themselves, the approval of those that really understand some of my work is even more important to me."